

GAO

United States General Accounting Office

Report to the Chairman, Committee on  
International Relations, House of  
Representatives

September 1999

# NUCLEAR NONPROLIFERATION

## Status of Heavy Fuel Oil Delivered to North Korea Under the Agreed Framework



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Resources, Community, and  
Economic Development Division

B-283603

September 30, 1999

The Honorable Benjamin A. Gilman  
Chairman, Committee on  
International Relations  
House of Representatives

Dear Mr. Chairman:

During the early 1990s, North Korea's nuclear program was suspected of producing nuclear material capable of being fashioned into nuclear weapons. To address this threat and ease tensions on the Korean Peninsula, the United States and North Korea signed an agreement known as the Agreed Framework on October 21, 1994.<sup>1</sup> Under this agreement, North Korea agreed to freeze the construction and operation of its existing nuclear reactors and related facilities, to eventually dismantle this equipment, and to comply with the international Treaty on the Non-Proliferation of Nuclear Weapons. In exchange, the United States pledged to help North Korea acquire two light-water nuclear reactors for electricity generation by arranging for their construction through an international consortium, the Korean Peninsula Energy Development Organization (KEDO).<sup>2</sup> Furthermore, to offset the energy forgone by the freeze on North Korea's nuclear reactors, the United States pledged to arrange through the organization for deliveries of 500,000 metric tons of heavy fuel oil annually until the first reactor was completed.<sup>3</sup> An agreement on the actual schedule for delivering the reactors has not yet been concluded. The Agreed Framework provides that the fuel oil is to be used for heating and electricity generation. However, reports have alleged that North Korea has diverted some of this heavy fuel oil for purposes not specified in the Agreed Framework, including resale abroad.

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<sup>1</sup>"Agreed Framework Between the United States of America and the Democratic People's Republic of Korea." The Democratic People's Republic of Korea is commonly known as North Korea.

<sup>2</sup>KEDO was established on Mar. 9, 1995, by the governments of Japan, the Republic of Korea (South Korea), and the United States. The governments of Argentina, Australia, Canada, Chile, the Czech Republic, Finland, Indonesia, New Zealand, and Poland have since joined the organization. In Sept. 1997, the European Atomic Energy Community—an organization of the European Union—joined KEDO and, with Japan, South Korea, and the United States, became a member of its Executive Board. The organization's activities are funded primarily by members' contributions.

<sup>3</sup>A KEDO consultant (Management Strategies, Inc.) estimates that in 1996, 500,000 metric tons represented 45 percent of North Korea's total annual heavy fuel oil needs.

This is our fourth report on issues related to the implementation of the Agreed Framework.<sup>4</sup> As agreed with your office, the report discusses (1) the status of heavy fuel oil funding and deliveries to North Korea undertaken pursuant to the U.S./North Korean Agreed Framework and (2) the controls in place to prevent the diversion of heavy fuel oil from heating and electricity generation to other purposes not specified in the Agreed Framework and any limitations in these controls that would allow North Korea to divert heavy fuel oil.<sup>5</sup>

## Results in Brief

As of July 31, 1999, 1.9 million metric tons of heavy fuel oil had been delivered to North Korea at an approximate cost of \$222 million. For the first 3 years of the Agreed Framework's implementation, shipments to North Korea did not occur on a regular and predictable schedule because KEDO—the organization that has arranged and paid for the majority of the heavy fuel oil shipments—did not always have sufficient funding to pay for heavy fuel oil deliveries. For the past 2 years, shipments of heavy fuel oil to North Korea have been made more regularly because of increased contributions from the organization's members and decreasing commodity and freight prices. Because of a recent rise in commodity and freight prices, a KEDO official stated that the organization would need about \$10 million in additional funding above existing or promised contributions in order to pay for the remaining 1999 heavy fuel oil deliveries.

The State Department and KEDO, with the cooperation of North Korea, have implemented a monitoring system at the seven heating and electrical generation plants that use KEDO-supplied heavy fuel oil. The purpose of this monitoring system is to ensure that the heavy fuel oil is used only for heating and electricity generation at the seven power plants. KEDO's portion of the system consists of meters to measure fuel flow, recorders that compile daily and cumulative flow data, and periodic monitoring visits to each plant. Power outages and the poor quality of North Korea's electrical power supply have affected the operation of the monitoring equipment. KEDO's monitoring system alone is not designed to provide complete assurance that the heavy fuel oil delivered to North Korea is being used as prescribed by the Agreed Framework. For example, there

<sup>4</sup>Our three earlier reports are entitled Nuclear Nonproliferation: Implications of the U.S./North Korean Agreement on Nuclear Issues (GAO/RCED/NSIAD-97-8, Oct. 1, 1996), Nuclear Nonproliferation: Implementation of the U.S./North Korean Agreed Framework on Nuclear Issues (GAO/RCED/NSIAD-97-165, June 2, 1997), and Nuclear Nonproliferation: Difficulties in Accomplishing IAEA's Activities in North Korea (GAO/RCED-98-210, July 7, 1998).

<sup>5</sup>A forthcoming GAO report addresses your concerns about alleged diversions of U.S. donations of food aid to North Korea through the World Food Program.

are no arrangements with North Korea for monitoring the large quantities of heavy fuel oil in storage or in transit to the plants consuming the heavy fuel oil. However, the U.S. government uses other national technical means to supplement KEDO's monitoring equipment to provide additional confidence that the heavy fuel oil is being used for heating and electricity generation. State Department officials have acknowledged that there is some evidence that perhaps 5 percent of the heavy fuel oil has been used for unauthorized purposes. However, according to State, there is no clear evidence of any significant diversion to unauthorized purposes of the 500,000 metric tons of heavy fuel oil delivered annually to North Korea.

## Background

Under the Agreed Framework, KEDO will purchase and supply North Korea with two light-water reactors with a combined total generating capacity of approximately 2,000 megawatts of electrical power to replace a graphite-moderated, 5-megawatt electric (MW(e)) power reactor; two unfinished graphite-moderated reactors—a 50-MW(e) power reactor and a 200-MW(e) power reactor—and related facilities, including a plutonium-reprocessing facility and a fuel rod fabrication facility. The United States pledged to arrange to provide alternative energy to North Korea in the form of heavy fuel oil for heating and electricity generation.

Heavy, or residual, fuel oil is used for thermal heating, in power generation facilities, and as fuel for ships. According to Department of Defense officials, the quantities of other fuels, such as gasoline, diesel, or kerosene, that can be extracted from heavy fuel oil are very small compared with the quantities that can be extracted from crude oil and other petroleum products. Further refining processes would be needed to extract such fuels from the heavy fuel oil.

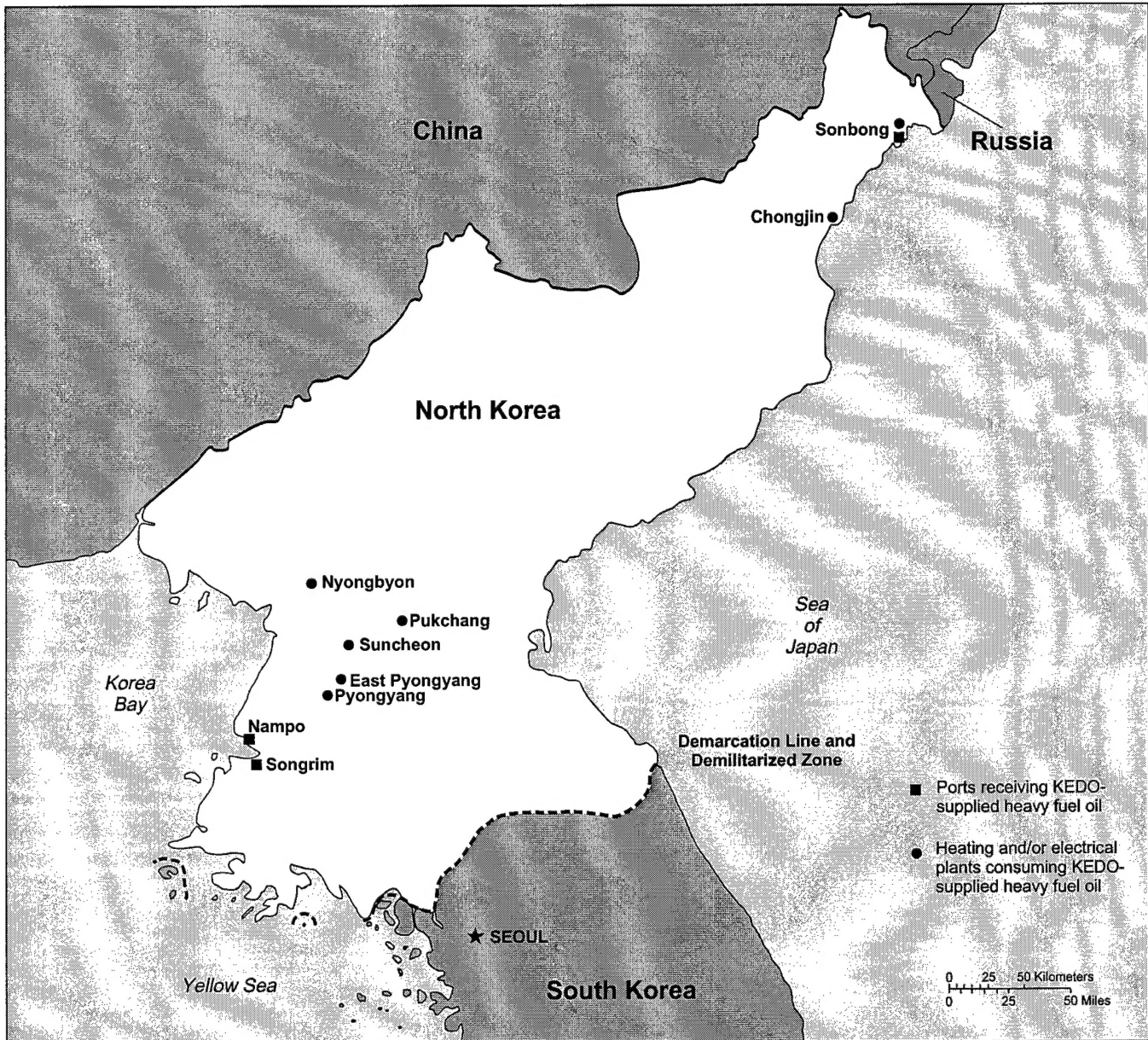
In June 1995, the United States and North Korea agreed that 150,000 metric tons of heavy fuel oil would be provided in the year ending October 20, 1995 (1 year after the signing of the Agreed Framework), and that deliveries totaling 500,000 metric tons would be made for each 12-month period thereafter until the first reactor was delivered. As stipulated in the Agreed Framework, the target date for completing the first reactor was 2003. However, an agreement on the actual schedule for delivering the reactors has not yet been concluded, and, as a result, the duration of the oil purchases and deliveries is not yet known.

Initially, 500,000 metric tons of heavy fuel oil represented the amount of fuel that could be consumed annually at one North Korean facility, the

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Sonbong Thermal Power Plant, which produces electricity for North Korea's North Hamgyong Province and thermal heat (steam) for the surrounding villages. This initial estimate was produced by calculating the amount of heavy fuel oil the Sonbong plant would consume if it operated at 100-percent capacity. However, the Sonbong plant has been operating at approximately 40-percent capacity, which, according to KEDO's contractor (Fluor Daniel, Inc.), should be considered normal for a North Korean power plant of Sonbong's age. Since June 1995, the United States and North Korea have agreed to expand the number of facilities allowed to consume heavy fuel oil. Currently, seven North Korean power and thermal facilities are consuming heavy fuel oil supplied by KEDO (see fig. 1). In addition to Sonbong, the Chongjin, Pukchang, Pyongyang, East Pyongyang, and Suncheon thermal power plants are approved to consume KEDO-supplied heavy fuel oil. In addition, Nyongbyon, the site of most of North Korea's frozen nuclear facilities, consumes heavy fuel oil in a small thermal plant used seasonally for district heating. Profiles of each of the facilities consuming this heavy fuel oil appear in appendix I. KEDO has purchased the heavy fuel oil on the open market from companies in Japan, Singapore, and South Korea using funds available from contributions from 24 countries (including the United States) and the European Atomic Energy Community.

Figure 1: North Korean Ports Receiving and Facilities Consuming KEDO-Supplied Heavy Fuel Oil



(Figure notes on next page)

Notes: 1. Since Oct. 1994, of the 1.9 million metric tons of heavy fuel oil delivered to North Korea, 1.2 million metric tons have been delivered to the port at Sonbong and 700,000 metric tons have been delivered to the ports of Nampo and Songrim.

2. The Sonbong and Chongjin thermal power plants are supplied with heavy fuel oil from the port at Sonbong. Nampo/Songrim supplies the East Pyongyang, Pukchang, and Suncheon thermal power plants and the Nyongbyon Thermal Plant. From Jan. through July 1996, the Pyongyang Thermal Power Plant was supplied with heavy fuel oil from the port at Sonbong. Since that time, Pyongyang has been supplied from Nampo/Songrim.

## Status of Heavy Fuel Oil Funding and Deliveries to North Korea

As of July 31, 1999, 1.9 million metric tons of heavy fuel oil had been delivered to North Korea at a cost of \$222 million (see table 1). Under an initial arrangement, in January 1995, the U.S. government provided approximately 50,000 metric tons of heavy fuel oil to North Korea approximately 2 months before KEDO was established. The \$5.5 million cost of this shipment was paid with Department of Defense funding appropriated for emergency and extraordinary expenses. KEDO has arranged all subsequent shipments to North Korea and paid the remaining costs of \$216.5 million for heavy fuel oil using (1) \$207 million contributed to the organization and available for heavy fuel oil purchases and (2) loans made to finance such purchases. Since the organization was created in March 1995, the United States has contributed \$148 million to it. Of this total, KEDO has used \$133 million for heavy fuel oil and \$15 million for its own administrative expenses. The remaining \$74.5 million in contributions available for heavy fuel oil purchases have come from the European Atomic Energy Community, Australia, and 21 other countries (see fig. 2).<sup>6</sup> In addition, Japan has contributed \$19 million to KEDO in the form of a collateral fund to be used as needed to pay for financing KEDO's expenses in case of a liquidity shortfall. This fund has been used to support loans made to finance heavy fuel oil purchases.

<sup>6</sup>The contributions were made to KEDO's heavy fuel oil account or its account for unrestricted or other purposes.

**Table 1: Quantity and Costs of Heavy Fuel Oil Deliveries**

<b>Heavy fuel oil delivery year</b>	<b>Quantity delivered (in metric tons)</b>	<b>Total cost</b>
1995 (Jan. 1995-Oct. 1995)	150,393	\$15,793,000
1996 (Nov. 1995-Oct. 1996)	500,000	67,353,000
1997 (Nov. 1996-Jan. 1998)	500,327	64,956,000
1998 (Feb. 1998-Feb. 1999)	499,910	48,695,000
1999 (Mar. 1999-July 1999)	246,777	25,549,000
<b>Total</b>	<b>1,897,407</b>	<b>\$222,346,000</b>

Notes: 1. Deliveries and costs for 1995 include a 50,000-metric-ton delivery whose \$5.5 million cost was paid by the Department of Defense.

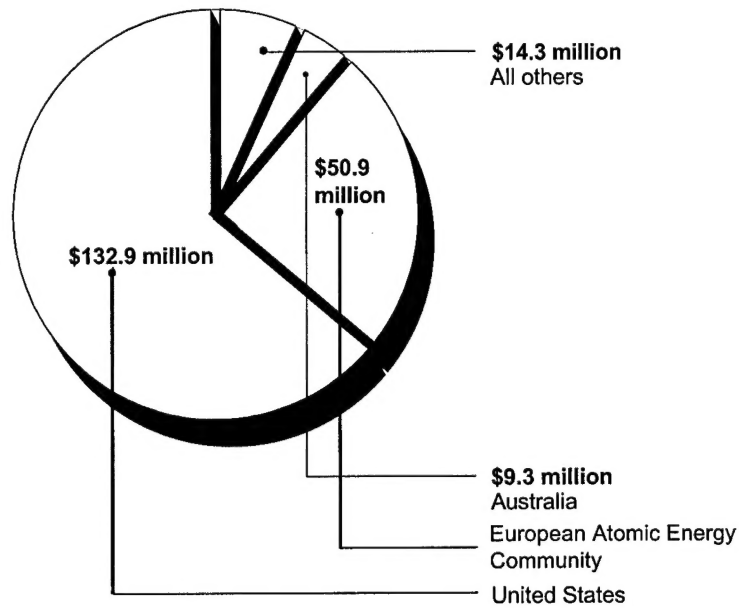
2. After 1995, under an agreement reached by North Korea and the United States, 500,000 metric tons of heavy fuel oil is to be delivered annually by Oct. 21. Because funding has been uncertain, KEDO has been unable to reach the 500,000-metric-ton annual allotment by Oct. 21 except in 1996. Shipments to meet the 1997 allotment extended until Jan. 1998, and deliveries for the 1998 allotment extended until Feb. 1999.

Source: GAO's analysis of data from KEDO.



**Figure 2: Contributions to KEDO  
Available for Heavy Fuel Oil Purchases  
as of July 31, 1999**

Dollars in millions



Notes: 1. Total contributions to KEDO available for heavy fuel oil purchases equal \$207.4 million.

2. Japan's contribution of \$19 million to KEDO—in the form of a collateral fund to be used as needed to pay for financing KEDO's expenses in case of a liquidity shortfall—is not included in the contributions above. This fund has been used to support loans made to finance heavy fuel oil purchases.

3. The United States' contribution does not include the \$5.5 million paid for heavy fuel oil deliveries before KEDO was created in Mar. 1995 or the \$15.1 million contributed to KEDO for its administrative expenses.

Source: GAO's analysis of data from KEDO.

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The total costs of \$222 million for providing heavy fuel oil to North Korea have been distributed as follows:

- Approximately \$215 million has been paid for commodity costs (to purchase heavy fuel oil) and freight costs (generally, to ship the heavy fuel oil from Japan, South Korea, or Singapore to North Korea).
- Approximately \$4 million has been paid in interest on credit extended from heavy fuel oil suppliers or on bank loans secured through the \$19 million loan collateral fund contributed by Japan.
- The remaining approximately \$3 million has been paid for demurrage charges—costs incurred when KEDO-contracted vessels delivering heavy fuel oil to North Korea are unable to discharge their cargo at the ports within the contracted period of time.

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### Past Deliveries of Heavy Fuel Oil to North Korea Were Irregular

In the first 3 years of the Agreed Framework's implementation, shipments to North Korea did not occur on a regular and predictable schedule because KEDO did not always have sufficient funding to pay for deliveries. KEDO's Executive Board establishes the schedule and amounts of the individual heavy fuel oil deliveries after determining (1) its ability to pay for those deliveries out of received or promised contributions to the organization and (2) North Korea's heavy fuel oil consumption and storage capacities. From August 1995 to October 1998, monthly shipments varied widely. In some months, KEDO made no deliveries while in 1 month—October 1996—it delivered a total of 103,500 metric tons (or over one-fifth of the annual requirement).

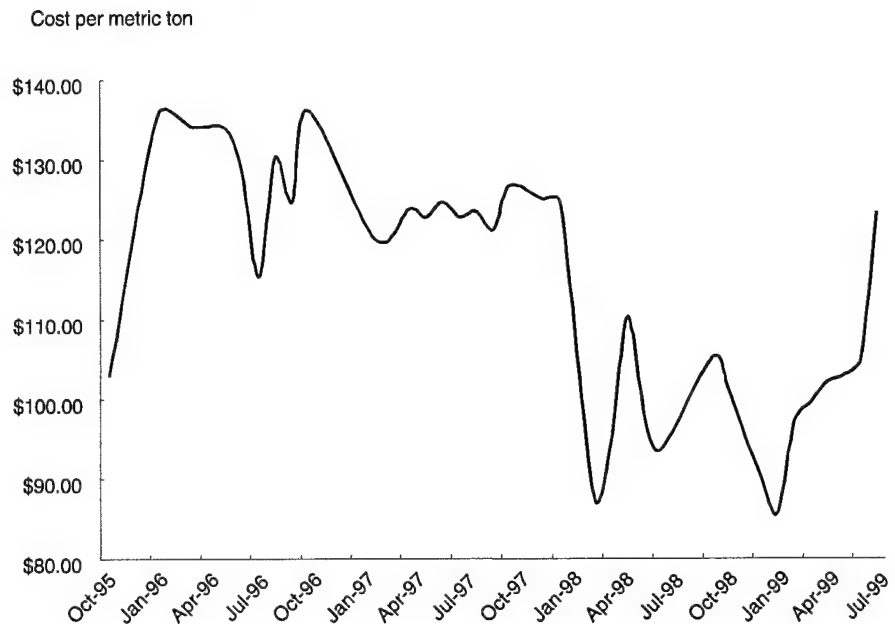
North Korea has complained about KEDO's inability to make regular heavy fuel oil shipments. North Korean officials have strongly argued that the organization should state that it would deliver the heavy fuel oil by a specific date and provide a schedule of all upcoming heavy fuel oil deliveries, including those for future years. The irregularity of shipments has also led to delays and additional costs to the organization. According to KEDO, North Korean ports are not well equipped to handle large quantities of incoming oil in a timely manner and have only limited storage and transportation capabilities. These conditions have led to delays by KEDO's suppliers in discharging their cargo, resulting in additional shipping costs to KEDO totaling approximately \$3 million. Delays have also occurred because of adverse weather and last-minute requests by North Korea for changes to delivery locations.

## Recent Heavy Fuel Oil Deliveries Have Been More Regular

We reported in June 1997 that, while KEDO could provide a broad base of financial support for implementing aspects of the Agreed Framework, it owed, as of May 1, 1997, about \$46 million in bank loans and credit extended by heavy fuel oil suppliers. Consequently, the organization had insufficient funds available to meet future oil commitments.<sup>7</sup> Since that time, KEDO's financial situation has improved, and, according to KEDO officials, its total debt for heavy fuel oil has been reduced to \$21 million, consisting of loans supported by the \$19 million collateral fund contributed by Japan and a \$2 million loan from KEDO's administrative fund. After January 1998, KEDO incurred lower costs to purchase and ship heavy fuel oil for over a year. From a high of over \$136 per metric ton in October 1996, commodity and freight costs fell to under \$86 in February 1999 (see fig. 3). However, these costs rose to \$123 per metric ton in August 1999. Increased contributions from the United States, the European Atomic Energy Community, and other members have allowed KEDO to pay for heavy fuel oil shipments in cash rather than on credit from heavy fuel oil suppliers. In 1997, the interest on such credit amounted to over \$2.2 million. Since June 1998, however, KEDO has paid for heavy fuel oil shipments in cash or through loans drawn against the \$19 million collateral fund contributed by Japan, reducing these interest costs.

<sup>7</sup>See Nuclear Nonproliferation: Implementation of the U.S./North Korean Agreed Framework on Nuclear Issues (GAO/RCED/NSIAD-97-165, June 2, 1997).

**Figure 3: Commodity and Freight Cost  
Per Metric Ton of Heavy Fuel Oil,  
October 1995-August 1999**



Source: GAO's analysis of data from KEDO.

According to KEDO officials, the organization's stronger financial condition has also increased the regularity of heavy fuel oil shipments to North Korea. In February 1999, for the first time, KEDO provided North Korea with a provisional schedule for heavy fuel oil deliveries for the 1999 delivery period (from late Mar. 1999 through Oct. 1999). This schedule was provided "with the understanding that the precise timing will depend upon the availability of funding, which . . . is subject to [the] approval of the legislatures of the countries that provide that funding." According to KEDO, more regular heavy fuel oil deliveries have allowed North Korea to better accommodate the shipments and have thus reduced the costs associated with shipping delays. In addition, KEDO and North Korea agreed in October 1997 that deliveries would not be scheduled until it could be assured that each delivery could be unloaded in a timely fashion, further reducing delays and the costs associated with them. With lower commodity, freight, interest, and demurrage costs, KEDO's total costs for heavy fuel oil dropped from \$135 per metric ton of heavy fuel oil in 1996 to

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\$104 per metric ton in the first 7 months of 1999, a total reduction of 23 percent.

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### KEDO's Ability to Make Remaining 1999 Heavy Fuel Oil Deliveries Is Uncertain

Although KEDO's finances have improved, uncertainties remain about the organization's ability to meet this year's obligations. Funding this year's remaining deliveries is dependent on receiving an expected \$14 million contribution from the European Union before October 1999. In addition, future costs for heavy fuel oil purchases cannot be estimated with any degree of confidence because the prices for oil commodities on the world market can differ significantly from their historical levels. As figure 3 shows, commodity and freight prices have risen sharply since February 1999 and these increases may hamper the organization's ability to fund the remaining 1999 deliveries. A KEDO official stated that the organization could find itself nearly \$10 million short before completing this year's 500,000-metric-ton allocation. This shortfall would likely be made up by seeking additional contributions from KEDO's members.

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### Controls in Place to Detect Diversion of Heavy Fuel Oil to Purposes Not Prescribed in the Agreed Framework

To provide assurance that the heavy fuel oil supplied is being used for heating and electricity generation as stipulated in the Agreed Framework, KEDO, on the basis of agreements it reached with the State Department, began to establish a heavy fuel oil monitoring system in mid-1995. This monitoring system consists of flow meters and data recorders installed at each of the sites that consume heavy fuel oil supplied by the organization to measure and record the flow of oil at each facility. In addition, KEDO and its contractor—Fluor Daniel, Inc.—conduct periodic monitoring visits to North Korea to maintain the flow meter system and retrieve the data stored in the data recorders. Power outages and the poor quality of North Korea's electrical power supply have affected the reliability of the monitoring equipment. There are also no arrangements with North Korea for monitoring the large quantities of heavy fuel oil in storage or in transit to the plants consuming the heavy fuel oil. An outage of KEDO's monitoring equipment from January-April 1999 at the facility consuming the largest amount of KEDO-supplied heavy fuel oil illustrates these problems. However, the U.S. government also uses other national technical means to complement KEDO's system, thereby providing additional confidence that the heavy fuel oil is used for heating and electricity generation. State Department officials have acknowledged that there is some evidence that perhaps 5 percent of the heavy fuel oil has been used for unauthorized purposes. However, according to State, there is no clear evidence of any

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significant diversion to unauthorized purposes of the 500,000 metric tons of heavy fuel oil delivered annually to North Korea.

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### The Heavy Fuel Oil Monitoring System Is Designed to Detect and Deter the Diversion of Heavy Fuel Oil

According to KEDO, the U.S. government designed the overall monitoring system to (1) detect significant diversions by North Korea of KEDO-provided heavy fuel oil to military or other prohibited uses, (2) detect to the extent possible smaller diversions of KEDO-supplied heavy fuel oil, and (3) deter North Korea from attempting such diversions. According to understandings reached with the State Department, the organization's responsibility for the monitoring system consists of (1) installing the flow meters and related monitoring equipment and collecting the data from that equipment, (2) visiting the facilities to service the equipment and exchange relevant information with North Korean technicians, (3) receiving information from North Korea on where the heavy fuel oil delivered to each North Korean port is intended to be consumed, and (4) meeting regularly with North Korea to further exchange views and collect information on the system's operation.

As part of its monitoring system at the facilities consuming heavy fuel oil supplied by the organization, KEDO uses two types of flow meters:

- Ultrasonic meters, which measure fuel flow rates using sound waves passed through oil pipes, are in use at four of the thermal power plants that consume KEDO-supplied heavy fuel oil.
- Coriolis meters, which directly measure the amount of fuel flowing through oil pipes, are in use at the other three plants.

Ultrasonic flow meters were installed at the Sonbong Thermal Power Plant in August 1995. After the State Department approved the consumption of KEDO-supplied heavy fuel oil at the six additional plants, KEDO installed fuel flow meters at each facility to track oil usage. As of April 1, 1999, the costs to install and maintain the equipment were about \$2.4 million and were paid for out of funds available for KEDO's heavy fuel oil purchases.

In March 1997, KEDO began installing data recording equipment capable of maintaining an historical record of meter readings to provide additional confidence in the accuracy of the readings provided by North Korea. Appendix I contains details on the specific features of the monitoring system at each of the North Korean plants that consume heavy fuel oil supplied by KEDO.

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KEDO receives the following three types of data from North Korea:

- North Korean personnel compile readings from the flow meters and fax them biweekly to KEDO.
- Consumption data based on measurements taken by North Korea of the amount of heavy fuel oil drawn out of each plant's oil supply system and holding tanks are also faxed to KEDO biweekly.
- The original printouts from KEDO's data recorders, showing daily and cumulative consumption of heavy fuel oil, are mailed to the organization within 3 weeks of the end of the biweekly reporting period.

In addition, the data recorders that the organization began installing in March 1997 at each of the plants consuming KEDO-supplied heavy fuel oil maintain a daily consumption history in solid-state memory. Fluor Daniel, Inc., KEDO's contractor, retrieves the historical data during regular monitoring visits, analyzes the data, and provides the organization with monthly and annual summaries of these analyses. KEDO then shares these reports with the State Department. In addition, Fluor Daniel assists KEDO in fulfilling its responsibilities by acquiring, installing, and maintaining components of the flow meter system.

KEDO officials also accompany the contractor on monitoring visits to North Korea to maintain the flow meter system's equipment and retrieve the data stored in the data recorders. These announced visits typically take place two or three times per year, with the exact dates and schedules agreed upon by KEDO and North Korea. KEDO officials stated that early logistic problems and difficulties completing required work in the mutually agreed-upon time have been overcome. North Korea has been cooperative during these trips, and, while some irregularities (e.g., unexplained invalid readings on the flow meter displays) have been noted by KEDO and Fluor Daniel field teams, there has been no evidence that North Korean personnel have interfered with the monitoring equipment. KEDO eventually hopes to increase the number of monitoring visits to four or six per year.

In addition, to complement KEDO's monitoring system, the U.S. government uses national technical means to ensure that the heavy fuel oil is being used for heating and electricity generation.

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### Problems Have Limited the Reliability of KEDO's Monitoring System

KEDO has experienced problems with its heavy fuel oil monitoring system. Monitoring equipment installed at each of the seven sites consuming KEDO-supplied heavy fuel oil has been subject to outages at various times

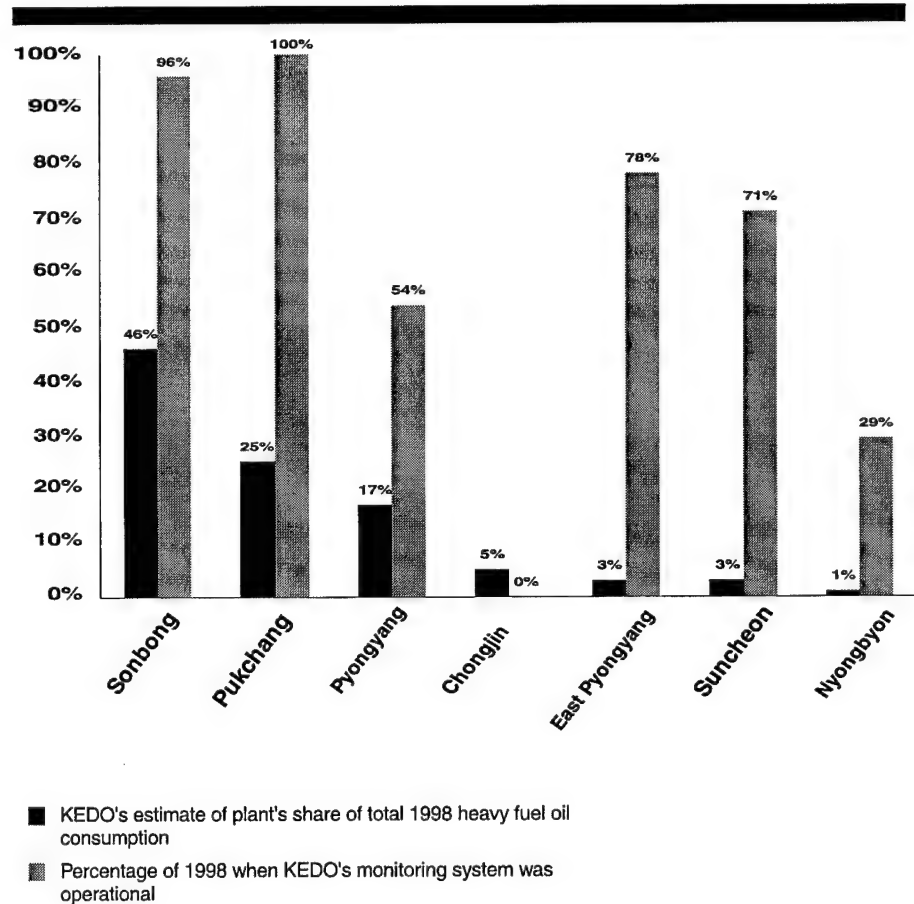
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since the system was installed. Neither KEDO nor Fluor Daniel has found evidence of tampering with the equipment that could have caused these outages. Rather, both organizations have attributed these problems to the poor quality of the electrical power (i.e., a widely fluctuating electrical frequency) available in North Korea. In 1998, these outages were more prevalent at plants where smaller amounts of heavy fuel oil are consumed. For example, at both the Sonbong and Pukchang thermal power plants, which together consumed 71 percent of the heavy fuel oil delivered, the KEDO monitoring system was operative 96 percent and 100 percent of the time, respectively, in 1998. The worst outages of the KEDO monitoring system occurred at Pyongyang, whose monitoring system was inoperative for 46 percent of the year, and at Chongjin, whose monitoring system did not operate at all during 1998. KEDO estimates that Pyongyang consumed 16 percent of the heavy fuel oil in 1998 while Chongjin consumed 5 percent. Power-conditioning equipment that was initially installed to compensate for the frequency fluctuations in the electrical power supplied to the monitoring equipment at the sites did not completely alleviate the problem. This equipment has since been replaced by more advanced equipment that KEDO hopes will allow the monitoring system to operate continuously.

In 1998, the first full year for which systematic analysis of the data on the operation of KEDO's monitoring system was completed, the system's reliability varied. As figure 4 shows, monitoring systems at the plants consuming KEDO-supplied heavy fuel oil were operational for varying periods of time throughout the year. In addition, in April 1999, the monitoring equipment KEDO had installed at the Pyongyang Thermal Power Plant was destroyed by a fire in the plant's control room. New equipment was installed in July 1999. During such outages, KEDO must rely on consumption figures reported by North Korean plant operators using measurement equipment that, KEDO states, is primitive by Western standards.



**Figure 4: Outages of KEDO's Monitoring System in North Korean Plants Consuming Heavy Fuel Oil During 1998**



Notes: 1. 1998 was the first full year for which systematic analysis of the data on the operation of KEDO's monitoring system was completed.

2. KEDO estimates that North Korea consumed a total of 445,000 metric tons of heavy fuel oil in 1998.

3. Nyongbyon operates as a heating facility during the winter months only. KEDO's monitoring equipment is not powered when the plant is inoperative.

Source: GAO's analysis of data from KEDO.

In addition, the accuracy of the ultrasonic flow meters installed initially at four of the seven plants (Sonbong, Chongjin, Pyongyang, and Pukchang) declines when lower amounts of heavy fuel oil flow through the facilities'

oil pipes. According to KEDO officials, low-flow conditions do not occur at Sonbong and Chongjin. At Pyongyang and Pukchang, however, low-flow conditions can occasionally occur and could affect the accuracy of the ultrasonic flow meters. Although such conditions could lessen the accuracy of the consumption data produced at these plants, the total error at any single facility would be in the range of 1 to 3 percent of the heavy fuel oil consumed at that plant. Coriolis meters, which are more accurate under these lower-flow conditions, have been installed at Suncheon, East Pyongyang, and Nyongbyon. Plans to replace the remaining ultrasonic flow meters with Coriolis meters have been curtailed because, according to KEDO officials, the existing ultrasonic flow meters at the facilities are sufficiently accurate, given the relatively infrequent occurrence of low-flow conditions at the Pyongyang and Pukchang plants. In any case, North Korea refused to allow the ultrasonic meters at Pyongyang to be replaced with Coriolis meters, stating that it could not allow the power plant to be shut down for the time required to complete the installation.<sup>8</sup>

The early monitoring equipment installed at North Korean plants was not designed to maintain a complete history of heavy fuel oil consumption. The flow meters did not have solid-state memory that kept a record of consumption. Furthermore, the time and date of the data printouts that North Korea mailed to KEDO were not stamped by the equipment, reducing the reliability of the printouts as a means of verifying heavy fuel oil consumption during a specific period of time at an individual plant. After discussing possible solutions to this problem with North Korea in 1996, KEDO began installing the previously discussed improved data-recording equipment in March 1997 at each of the seven locations that consume heavy fuel oil. In addition to producing daily printouts of flow meter data, these recorders retain consumption data in solid-state memory, which KEDO teams can download to computers during monitoring visits. In 1998, the data were used to develop a comprehensive database of daily heavy fuel oil consumption for the first time.

Upgraded power conditioners should, KEDO believes, correct the problems with the poor quality of North Korea's electric power and its effects on KEDO's monitoring equipment. In addition, the installation of data recorders has increased the organization's confidence in its consumption data. However, KEDO's system alone is not designed to provide complete assurance that the heavy fuel oil delivered to North Korea is being used as

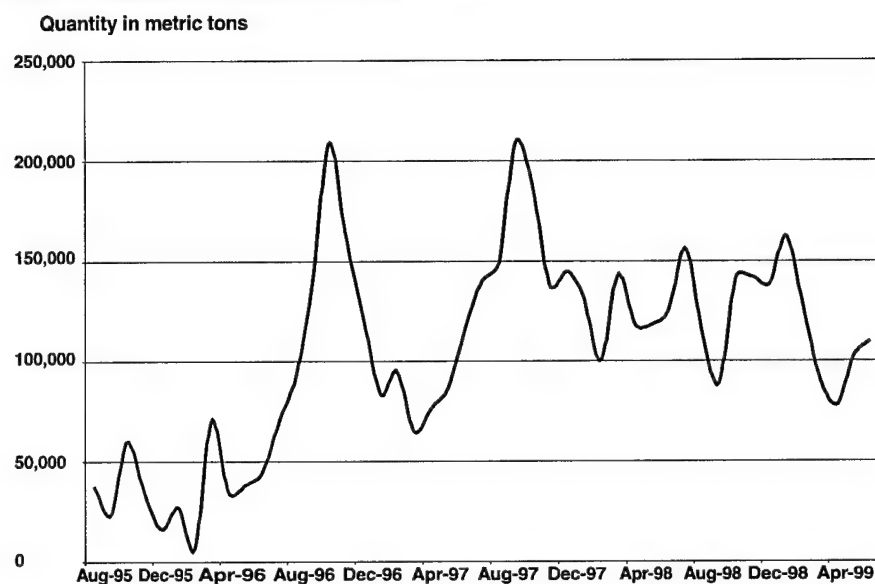
<sup>8</sup>Ultrasonic meters, which are attached to the outside of oil pipes, can be installed without interrupting a power plant's operations, while Coriolis meters, whose installation entails cutting and welding oil pipes, requires that the power plant cease operations until the installation is complete.

prescribed by the Agreed Framework.<sup>9</sup> There are no arrangements with North Korea for monitoring the large quantities of KEDO-supplied heavy fuel oil in storage or in transit to the facilities where it will be consumed.<sup>10</sup> According to a State Department report, North Korea has acknowledged storing a large quantity of KEDO-supplied heavy fuel oil in response to the irregularity of heavy fuel oil deliveries. Using consumption data reported by North Korea, as of the end of June 1999, about 110,000 metric tons of heavy fuel oil, or 22 percent of North Korea's annual allotment and nearly 6 percent of the total heavy fuel oil delivered to North Korea from January 1995 to July 1999, was being stored (see fig. 5). According to KEDO officials, the heavy fuel oil is being stored in a large number of storage tanks and excavated open storage pits at the delivery ports and at the plants where the heavy fuel oil is being consumed. In addition, there is no arrangement specifying that North Korea segregate KEDO-supplied heavy fuel oil from the heavy fuel oil North Korea obtains from other suppliers. Furthermore, monitoring equipment is not installed on the numerous railcars and pipelines used to transport the heavy fuel oil from the delivery ports to storage and from storage to the plants where the heavy fuel oil is to be consumed. KEDO is thus unable to track the heavy fuel oil from the time it is unloaded from delivery vessels at Sonbong, Nampo, or Songrim to the time it passes through the flow meters at the plants where it is eventually consumed. KEDO, during its monitoring visits, has observed storage facilities at the seven plants; however, it cannot confirm that these are the only facilities where KEDO-supplied heavy fuel oil is being stored.

<sup>9</sup>As previously discussed, the U.S. government uses national technical means to complement KEDO's monitoring system so as to provide additional assurance that the heavy fuel oil supplied to North Korea is being used for heating and electricity generation.

<sup>10</sup>According to State Department officials, when the monitoring system was designed, monitoring of storage facilities was considered but rejected as impractical, since it would require dedicated storage tanks for KEDO-supplied heavy fuel oil and would add little to the capability of the monitoring system.

**Figure 5: KEDO-Supplied Heavy Fuel Oil in Storage, August 1995-June 1999**



Note: The quantity of heavy fuel oil in storage is estimated by subtracting North Korea's reported consumption from the quantity of heavy fuel oil delivered.

Source: GAO's analysis of data from KEDO.

### Early 1999 Outage of Equipment at Sonbong Illustrates Problems With KEDO's Monitoring System

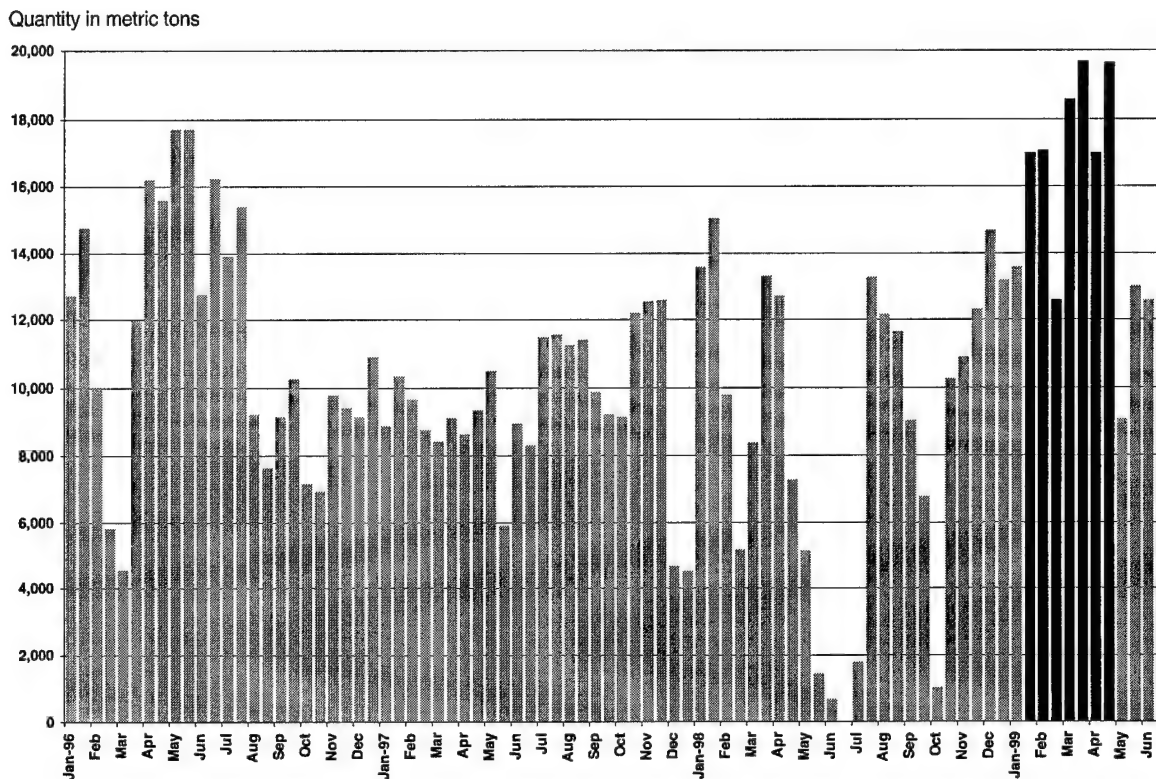
According to KEDO, since 1995, the Sonbong Thermal Power Plant has consumed over half of the heavy fuel oil supplied by the organization. KEDO's monitoring equipment became inoperative on January 18, 1999, because of the poor quality of the electrical power available at the power plant. The problem was corrected on April 26, 1999, when KEDO installed an upgraded power-conditioning unit and was able to restart the monitoring equipment. During this outage lasting over 3 months, the only data showing the consumption of heavy fuel oil at Sonbong were provided by North Korea. These data were based on the levels of heavy fuel oil in Sonbong's storage facilities. However, since KEDO has no monitoring equipment installed at these storage facilities, it could not verify this information.

During this period, North Korea reported that heavy fuel oil was being consumed at levels substantially exceeding those historically recorded at Sonbong (see fig. 6). According to a Fluor Daniel representative, the plant typically operates only one or two of the three boilers at the same time at

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the facility, and at least one of those boilers operates at less than maximum levels. The representative characterized the consumption data reported by North Korea during the monitoring equipment outage as historical highs for Sonbong as a whole, noting that such consumption would have required all three boilers to operate continuously at close to the highest levels ever recorded for each of them. For example, during the 6 months before the outage of KEDO's monitoring equipment, the average consumption of heavy fuel oil reported by North Korea was approximately 10,700 metric tons biweekly, or over 3,500 metric tons per boiler. During the 3 months when the organization's monitoring equipment was not operating, the average consumption of heavy fuel oil reported by North Korea increased by 62 percent to over 17,300 metric tons biweekly, or nearly 5,800 metric tons per boiler. After the repair of KEDO's equipment was completed on April 26, 1999, North Korea's reported consumption dropped to an average of 11,500 metric tons biweekly, or over 3,800 metric tons per boiler through the end of June.

**Figure 6: North Korea's Reported Biweekly Consumption of Heavy Fuel Oil at Sonbong Thermal Power Plant, January 1996-June 1999**



Notes: 1. North Korea's reported consumption during the Jan. 18-Apr. 26, 1999, period when KEDO's monitoring equipment was inoperative is shown in black.

2. A similar period of reported high consumption, from Apr.-July 1996, occurred before KEDO had installed data recorders at the Sonbong facility. Verifying these consumption data would involve detailed analysis of flow meter printouts from the period. These printouts did not have the time or date stamped by the equipment. To date, neither KEDO nor Fluor Daniel has performed this analysis.

Source: GAO's analysis of data from KEDO.

When KEDO officials inquired about this increase in reported consumption during the outage and the sudden return to nearly normal consumption after the equipment was restored to operation, North Korean officials

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responded that a lack of hydropower during the winter months required increased consumption of heavy fuel oil to generate electricity. However, the failure of KEDO's monitoring equipment leaves no way for the organization to verify this. Consumption during the winters of 1996, 1997, and 1998 did not show a similar large increase. In addition, North Korean officials reported that some of the heavy fuel oil leaked out of an open storage pit. Since North Korean consumption data are based on storage levels, leakage from the facilities would cause errors in consumption data, according to the North Korean officials responding to KEDO's inquiry. However, with no monitoring equipment installed to determine the amount of oil in these storage facilities, KEDO could not confirm that this leakage contributed to the discrepancy. According to State Department officials, U.S. and KEDO officials plan to pursue this questionable consumption through talks with their North Korean counterparts.

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### The State Department Has Confidence That the Heavy Fuel Oil Has Largely Been Used as Prescribed by the Agreed Framework

KEDO officials stated that the organization's responsibility to track heavy fuel oil consumption extends only to the installation, maintenance, and collection of data from the flow meter system at each of the facilities consuming KEDO-supplied heavy fuel oil and to periodic visits to each of these sites. According to KEDO officials, the United States is responsible for any other monitoring (e.g., monitoring of heavy fuel oil in North Korea's storage facilities or in transit to the power plants) and for determining whether any diversion has taken place. KEDO officials stated that they currently have no plans, nor do they have the resources, to expand the organization's monitoring regime beyond its current level. KEDO officials also emphasized that, to date, neither they nor the organization's contractor has found evidence indicating an effort on North Korea's part to subvert KEDO's monitoring system.

The State Department reported to the Congress in March 1999 that KEDO's monitoring arrangements, along with other U.S. national technical means, give the Department confidence that the heavy fuel oil supplied by the organization has largely been used in the manner prescribed by the Agreed Framework. State Department officials have acknowledged that there is some evidence that perhaps 5 percent of the heavy fuel oil has been used for unauthorized purposes. However, according to State, there is no clear evidence of any significant diversion to unauthorized purposes of the 500,000 metric tons of heavy fuel oil delivered annually to North Korea.

State Department officials believe that the current level of monitoring using KEDO's equipment and the U.S. government's national technical

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means is sufficient to ensure that the heavy fuel oil delivered to North Korea is not diverted to military uses or sold abroad. They reiterated that heavy fuel oil is not useful for purposes other than heating and electricity generation. While it is theoretically possible to extract other types of fuel from this oil, State Department officials stated the process would be so inefficient that there would be little incentive to do so. The current monitoring regime, the officials said, serves as a good tool to ensure that North Korea is abiding by its commitments to the United States.

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## Agency Comments

We provided a draft of this report to KEDO and the Department of State for their review and comment. KEDO and State Department officials, including the Deputy Assistant Secretary for East Asian and Pacific Affairs, generally agreed with the report's findings and provided comments to improve the technical accuracy of the report that we incorporated as appropriate.

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## Scope and Methodology

To obtain information for this report, we reviewed and analyzed the Agreed Framework and subsequent agreements, applicable U.S. laws, reports of congressional hearings, and supporting material provided by the State Department under the certification requirements imposed on U.S.-provided aid to North Korea. We also reviewed and analyzed documentation provided to us by KEDO, including heavy fuel oil delivery, consumption, and storage data; KEDO annual reports; monthly and annual consumption data summaries prepared by KEDO's contractor, Fluor Daniel, Inc.; KEDO Executive Board resolutions; and reports submitted by KEDO officials and Fluor Daniel personnel following their monitoring trips to North Korea. In addition, we reviewed a report prepared by Management Strategies, Inc., an independent consultant, on monitoring the use of KEDO-supplied heavy fuel oil. We also interviewed cognizant officials from the Department of State, KEDO, and Fluor Daniel, Inc. Given our past difficulties in obtaining North Korea's views, we did not attempt to contact officials from North Korea. We conducted our review from May 1999 through September 1999 in accordance with generally accepted government auditing standards.

As agreed with your office, we plan no further distribution of this report until 30 days after the date of this letter. At that time, we will send copies to the appropriate congressional committees; the Honorable Madeleine K. Albright, Secretary of State; the Honorable William S. Cohen, Secretary of Defense; L. Desaix Anderson, the Executive Director of KEDO; and other interested parties.



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If you have any questions about this report, please call me at (202) 512-3841 or Gene Aloise at (202) 512-6870. Other key contributors to this assignment were Ryan T. Coles and Victor J. Sgobba.

Sincerely yours,

A handwritten signature in cursive script that reads "Gary L. Jones". The signature is written in black ink and is positioned above the printed name and title.

(Ms.) Gary L. Jones  
Associate Director, Energy, Resources,  
and Science Issues



# Contents

Letter		1
Appendix I		28
Profiles of North Korean Power/Thermal Facilities Consuming KEDO-Supplied Heavy Fuel Oil and KEDO-Installed Monitoring Systems		
Table	Table 1: Quantity and Costs of Heavy Fuel Oil Deliveries	7
Figures	Figure 1: North Korean Ports Receiving and Facilities Consuming KEDO-Supplied Heavy Fuel Oil	5
	Figure 2: Contributions to KEDO Available for Heavy Fuel Oil Purchases as of July 31, 1999	8
	Figure 3: Commodity and Freight Cost Per Metric Ton of Heavy Fuel Oil, October 1995-August 1999	11
	Figure 4: Outages of KEDO's Monitoring System in North Korean Plants Consuming Heavy Fuel Oil During 1998	16
	Figure 5: KEDO-Supplied Heavy Fuel Oil in Storage, August 1995-June 1999	19
	Figure 6: North Korea's Reported Biweekly Consumption of Heavy Fuel Oil at Sonbong Thermal Power Plant, January 1996-June 1999	21

## Abbreviations

GAO	General Accounting Office
KEDO	Korean Peninsula Energy Development Organization
MW(e)	megawatt electric



# Profiles of North Korean Power/Thermal Facilities Consuming KEDO-Supplied Heavy Fuel Oil and KEDO-Installed Monitoring Systems

Facility	Generating capacity (MW(e))	Number of boilers	Number/type of flow meters	Estimated storage capacity (metric tons of heavy fuel oil)	Share of total heavy fuel consumption (Aug. 1995-June 1999)
Chongjin Thermal Power Plant	150	4	4 ultrasonic flow meters installed on the heavy fuel oil supply line at each boiler	21,200 (includes 20,000 at nearby Kimchaek iron and steel works)	5 percent
East Pyongyang Thermal Power Plant	150	3	6 Coriolis-type flow meters installed on the heavy fuel oil supply and return lines at each boiler	1,000	2 percent
Nyongbyon Thermal Plant	Used seasonally for district heating/no power output	3	3 Coriolis-type flow meters installed on the heavy fuel oil supply lines at each boiler	2,000	1 percent
Pukchang Thermal Power Plant	1,500	16 (1 set of 6 boilers and 1 set of 10 boilers)	4 ultrasonic flow meters installed on the common heavy fuel oil supply and return lines on each set of boilers	12,000	15 percent
Pyongyang Thermal Power Plant	500	14	2 ultrasonic flow meters installed on the common heavy fuel oil supply and return lines that serve the entire plant	17,000 (includes estimated 15,000 in open-pit storage)	15 percent
Sonbong Thermal Power Plant	200	3	3 ultrasonic flow meters installed on the heavy fuel oil supply line at each boiler	225,000 (includes 10,000 at power plant, 90,000 at nearby refinery tank farm, and an estimated 125,000 in open-pit storage)	59 percent
Suncheon Thermal power plant	200	4	8 Coriolis-type flow meters installed on the heavy fuel oil supply and return lines at each boiler	1,000	2 percent

(Table notes on next page)

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**Appendix I**  
**Profiles of North Korean Power/Thermal**  
**Facilities Consuming KEDO-Supplied Heavy**  
**Fuel Oil and KEDO-Installed Monitoring**  
**Systems**

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Notes: 1. Sonbong Thermal Power Plant is oil fired. Nyongbyon Thermal Plant is used only for steam heating. The other power plants are coal plants modified to burn a mixture of coal and heavy fuel oil.

2. Each facility consuming KEDO-supplied heavy fuel oil also has a data recorder installed that prints a daily consumption report and logs accumulated consumption data to a solid-state history memory every 6 hours. Every facility except for Nyongbyon also has upgraded power-conditioning units installed to compensate for the unreliable and poor-quality power sources available at the sites. Nyongbyon operates only during the winter months, and KEDO officials plan to install an upgraded power-conditioning unit before the plant begins operation for the season at the end of 1999.

3. In addition to the storage available at each facility, storage capacity of 9,000 metric tons is available at the port of Nampo and of 11,000 metric tons at the port of Songrim.

4. Estimates of the design specifics of the above North Korean facilities and heavy fuel oil storage capacity are based on data provided by North Korea to KEDO.

Source: GAO's presentation of data from KEDO.

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